12h. G.M.T.	R.A. h. m.	Decl. ° ′	Distance from Earth	Distance from Sun
August 16	7 7·7	+ 8 8	1·282	0·815
18	7 20·0	8 46		
20	7 32·5	9 25	1·280	0·766
22	7 45·2	10 2		
24	7 58·0	10 37	1·284	0·720
26	8 11·0	11 10		
28	8 24·2	11 40	1·295	0·679
30	8 37·5	12 8		
September 1	8 51·0	+12 33	1·312	0·644

If we suppose an acceleration of four days in the time of perihelion passage, the effect on the geocentric position is—

	m.		° ′
On August 16, in R.A.	+ 15·1.	in declination	+ 2 1
On ,, 28, ,,	+ 16·7,	,,	+ 1 41

The theoretical intensity of light expressed in the usual manner would be 0·92 on August 16, and 1·40 on September 1.

During the above period, with the places assigned, the comet would rise at Greenwich from 2h. 10m. to 2h. 20m. before the sun. In 1873, when the circumstances approached nearest to those of the return in the present year, the comet was detected at Marseilles on the morning of September 2, the distance from the earth being 1·02, and that from the sun 0·94, the intensity of light 1·08. At its last appearance in 1879 it was seen by Tempel at Arcetri, on January 14, when the intensity of light was only 0·13, an exceptional case, since at no previous appearance had it been observed under a less value than 0·33.

From the first discovery of the comet in 1846 by Brorsen, an astronomical amateur at Kiel, the period of revolution has gradually diminished from the effect of the planetary perturbations; subjoined are the times of perihelion passage in those years when the comet has been observed, and the sidereal periods corresponding to those times:—

			Days
1846	February 25·37	G.M.T.	2034·1
1857	March 29·25	,, ...	2022·7
1868	April 17·41	,, ...	2002·4
1873	October 10·48	,, ...	1999·4
1879	March 30·54	,, ...	1994·9

From its unfavourable position the comet was missed at its returns in 1851 and 1862. It is well known that the present orbit is due to the action of the planet Jupiter in 1842: at the perijove passage at 6 p.m. on May 27 in that year the comet's distance from Jupiter was 0·0547 of the earth's mean distance from the sun; consequent upon this near approach, the inclination of the orbit in which it previously moved was diminished nearly 15° according to the calculations of Dr. Harzer, who has very fully investigated the circumstances It is probable that there had been a great perturbation of the elements from the same cause in 1759-60, and that in 1937 (according to D'Arrest) this may again occur.

THE BINARY-STAR β DELPHINI.—Dr. Dubjago, of the Observatory at Pulkowa, has published a first orbit of this star, the duplicity of which was discovered by Mr. Burnham in 1873; more than 180° of the orbit have been described since that year. The period found is 26·07 years, the periastron passage at 1882·19. After that most rapid of all the known revolving double-stars δ Equulei, to which Mr. Burnham attributes a period of only 10·8 years, there is only one, 42 Comæ Berenicis, that has a shorter revolution attached to it, and β Delphini may be eventually proved to have the less period. In 1873 Mr. Burnham estimated the distance of the components 0″·7; they have since closed until the star has been beyond the powers of any but the largest telescopes. Dr. Dubjago's elements assign for 1884·6 position 219°·4, distance 0″·28.

RED SUNSETS[1]

THE equatorial diameter of the earth is 7901 miles and the circumference is 24,825, and as she revolves once on her axis in twenty-four hours, a place on the equator moves through 1034 miles in an hour: but at any depth beneath the surface the velocity is less in proportion to that depth; in like manner, if we look on the atmosphere as part and parcel of the earth, at a certain height the velocity is greater in proportion to that height.

The whole world has been greatly interested during the last seven or eight months with the beautiful phenomena of coloured suns and brilliant sunsets; and the liveliest interest has been exhibited as to their origin. Lockyer was the first, I believe, to point out the fact of the phenomenon of coloured suns appearing first in the east and then gradually shifting to the west. He traces them to Panama, and speaks of them as having been seen on a north-south line; but it strikes me that after leaving Panama the phenomenon passed still further westward, was seen on September 3, 4000 miles west of Panama, and at Honolulu on September 5, and struck India and Ceylon on the 8th, thus performing more than a complete circuit of the globe; moreover, I am of opinion that it may be traced still further westward, where it was seen in lat. 24° 6′ N., long. 140° 29′ W., by Capt. Penhallow of the barque *Hope*, on September 25, having then performed 2¾ revolutions of the globe.

All the information that I have collected, and from which I have compiled the following tables, has been obtained from NATURE. The time column has been deduced from the time and date of the phenomenon appearing at the different stations, reduced to Krakatoa time; in some instances great difficulty has been experienced, especially in reference to the time at Maranham in Brazil, and at Trinidad, and it has been concluded that at those stations the times are late, because it was seen at Panama before the time given at them, which we suppose to be an error. Likewise in the case of the Gold Coast, in one place the date given is August 30, and in another September 1, but from the general result it would appear to have reached that locality about midnight August 30–31.

The tables, I trust, are sufficiently clear; the first column of miles represents the mean diurnal velocity that the cloud travelled at between Krakatoa and the different localities *en route;* and in the subsequent columns are given the same from each station in rotation. Of course it will be understood that a small error of an hour or two in the time at the stations comparatively close to the eruption would make a large difference where we show the *diurnal* velocity; and as I have had only a week's notice to prepare this paper, I trust that any errors that may be hereafter found will be treated with that consideration.

TABLE I.—*Showing the Mean Diurnal Velocity in English Miles of the Phenomena of Coloured Suns and Brilliant Sunsets in the Northern Hemisphere*

	Time from Java to	Java	Seychelles	E. Coast of Africa	Gold Coast	Maranham	Trinidad	Panama	4000 miles W. of Panama	Honolulu	India
	h.										
Seychelles	45	1802									
E. Coast of Africa...	58	1817	1873								
	days										
Gold Coast	4	1846	1969	1932							
Maranham	5	2020	1950	1896	1904						
Trinidad	5¾	1968	2080	2040	1940	2176					
Panama	6¾	2059	2040	2176	2324	1930	1986				
4000 miles W. of Panama ...	8¼	2061	2424	2210	2493	2370	2338	2000			
Honolulu	9¼	1900	2084	2080	2036	1909	1748	1716	1122		
India...	12¼	2162	2278	2192	2328	2212	2084	2200	2310	2244	
Lat. 24° N., long. 140° 30′ W. ...	29⅜	2132	2246	2206	2268	2165	2400	2170	2460	2316	2192
Arithmetical means...		1976	2105	2091	2185	2127	2111	2022	1964	2280	2192
True mean...		2095									

Arithmetical mean for Northern Hemisphere 2105 miles per day.

The true mean of the first column, viz. that under the head of Java, is obtained by adding the distance between Krakatoa and each separate station together, and dividing the aggregate by the gross total number of days. The way by which the distance between any two stations is derived is by multiplying the difference in degrees of longitude by the value of a degree in English miles for the mean latitude of the two places. It must be remembered that between India and the last-named locality on the list the dust cloud is supposed to have performed over a revolution and a half of the earth.

I place great confidence in the result obtained from the observations deduced from India, because there there are scores of trained meteorological observers whose duty it is to immediately report any phenomena that may take place, and such as that concerning which I speak could not have escaped their immediate

[1] Paper read by Alexander Ringwood at an ordinary meeting of the Canterbury Philosophical Institute, New Zealand, on May 1, 1884.

notice; so we may conclude that the hour of its arrival there is very accurately determined, which gives a mean daily velocity of 2162 miles; and taking the velocity from its journey and a half round the world, from India to lat. 24° N., long. 140½° W., we find it to be 2192 miles per day, or 30 miles only in excess of the other computation. But if we take the whole journey from Krakatoa to that locality, about 2¾ revolutions round the globe, we find the mean to be 30 miles less than the first, or 2132 miles, and that will be accounted for through the diminished value of the degree in longitude at the mean latitude between Java and lat. 24° N., long. 140½° W.

The mean diurnal velocities obtained from the intermediate stations, between Java and India, agree very closely; when we consider that at those several places the phenomenon was wholly unexpected, and thus in most instances the dates and times given appear to be somewhat late, it is quite possible and natural that it escaped notice at least once; in India, however, we may conclude that they were on the alert, and consequently the mean velocity deduced from that place ought to bear great weight. There is another thing that ought not to be lost sight of, viz. that without this list of stations, more than encircling the globe, one might suppose that the *cloud* after leaving Krakatoa stretched away westward, and as I gather from Lockyer's paper by his *north–south* line, to have extended to the north and south, forming a letter V with the apex at the Straits of Sunda. Now Lockyer tracks it to Panama, to which place we see it to have had a diurnal velocity of 2059 miles, and from Panama to India I made it 2200 miles per day, which makes me believe that the cloud was performing a spiral path northward round the globe.

Before proceeding I will now turn to the observations in the Southern Hemisphere, in order to see whether the same has taken place there. This table has been prepared in like manner to the former, viz. the dates and times are reduced to that of Krakatoa, and the distances in English miles obtained from the difference in degrees of longitude reduced to the value of the mean latitude of the two places.

TABLE II.—*Showing the Mean Diurnal Velocity in English Miles of the Phenomena of Coloured Suns and Brilliant Sunsets in the Southern Hemisphere*

	Time from Java to	Java	Mauritius	Adelaide	Cape of Good Hope
	hours				
Mauritius	44 days	1680			
Adelaide	21¼	2041	1980		
Cape of Good Hope	24	2082	2047	2010	
Christchurch	29¼	2134	1990	2120	2070
Arithmetical means		1984	2005	2065	2070
True mean		2100			

Arithmetical mean for Southern Hemisphere 2031 miles per day.

The marked similarity between these two tables is most striking, and, as in the first table, the greatest discrepancy is found between Krakatoa and Mauritius, where the data are reckoned in so many hours, in which case an hour or two makes a material difference in the diurnal velocity. At present I cannot find any station reporting the phenomenon between Mauritius and Adelaide, but we may conclude that after it passed Mauritius it crossed Africa, the South Atlantic, and South America, whence we may expect to hear of it, as there are many competent observers in that part of the world; it then traversed the great South Pacific Ocean and North Australia, and after performing another such journey round the world, but in a higher latitude, was seen at Adelaide in South Australia about September 17. I conclude, as Mr. Todd, the Government Astronomer, there says in his report to NATURE, "that it was visible during the last fortnight of September." We next hear of it at the Cape of Good Hope on September 20. It again crossed the South Atlantic and South America about the latitude of Buenos Ayres, and a third time traversed the South Pacific, striking the coast of New Zealand on September 25, the date of my first seeing it; on which occasion the western sky at sunset presented all the colours seen in the pearl-shell. Since then the western and eastern skies have presented those beautiful crimson tints that have delighted the world, and on many occasions I have seen it almost in the zenith two hours after sunset. During some evenings it has quite illuminated the western face of buildings with a bright glare as from a fire, whilst on others it has been very faint and sometimes not discernible: giving to my mind the idea of its not being a continuous band but a series of dust clouds with clear spaces between.

From an investigation of the two tables it will be seen that the mean diurnal velocity in the Northern Hemisphere was, during the first revolution, about 2162 miles, and during the second it increased to 2192, or 30 miles per diem extra. And the same increased velocity is observed in the Southern Hemisphere, where we find the approximate velocity during the first two revolutions, viz. on its reaching Adelaide, to be 2041, whereas during the next revolution from Adelaide round to New Zealand it was 2120 miles, or an increase of 80 miles per day. It will be further noticed that in the Northern Hemisphere the time occupied in its first revolution was about eleven days, and the same rate is observed during the next revolution and three-quarters, or, in other words, within the tropics it encircled the world in eleven days. It is the same within the southern tropics, where it took 21¼ days to reach Adelaide in its second revolution, but it performed the next revolution in about 9½ days, reaching New Zealand in 29¼ days after the eruption. Thus it performed 2¾ revolutions in the Northern Hemisphere in 29⅝ days, and in the Southern Hemisphere it performed 2⅞ revolutions in 29¼ days, showing that the initial velocity at starting has only very slightly fallen off in even latitude 45° S. So in the following discussion I will adopt a mean diurnal velocity for the dust cloud of 2083 miles, or 87 miles per hour to the westward.

As I showed at the beginning that, if the atmosphere be considered as part and parcel of the earth, a particle of it at a certain height will cover a greater distance in a certain time than that part of the earth immediately beneath would, so if we know the rate per hour that a certain thing *apparently* moves to the westward, or seems to lag behind the diurnal revolution, we can ascertain the height. We know that it lags behind at the rate of 2083 miles per day, which, added to the circumference of the world, gives a circle of 26,908 miles, and this divided by 3·1416 gives a diameter of 8565 miles, or 664 miles greater than that of the earth, or a height of 332 miles above the surface. Or, putting it this way, we may assume that at the latitude of Krakatoa the earth has an hourly velocity of 1034 miles, and that any matter ejected thence into the upper regions of the atmosphere, would retain the same rotary velocity as it had before, viz. 1034 per hour to the eastward; but we have material under our observation which cannot keep its zenithal position at starting, by 87 miles per hour, showing it to be at an elevation of 332 miles.

Now the spectroscope tells us that the red colour is produced through dust of almost ultra microscopic fineness, and in some specimens of this dust that have already fallen the microscope shows the existence of *salt* crystals, which fact in itself almost proves it to be of volcanic origin, and not meteoric or cosmic dust. Now Prof. Helmholtz states that "the reflecting medium, whatever it was, over Berlin on the last three nights of November, was about 40 miles above the earth;" and if we work on this data we have a circle whose diameter is 80 miles greater than that of the earth, or a circle of 7981 miles, which, multiplied by 3·1416 gives a circumference of 25,073, or 248 miles more than that of the earth, which, divided by 24, shows an excess of about 10⅓ miles per hour above the surface velocity of rotation. But we want to account for an excess of 87 miles per hour; so if we accept Prof. Helmholtz's statement we must only suppose that at the altitude of 40 miles there is an easterly current, or one moving to the westward, of 77 miles per hour; for, assuming as we do from the foregoing tables and calculations that the earth rolls from under the cloud at the rate of 87 miles per hour, unless we admit of an easterly current we cannot stop short of that enormous height of 332 miles unless we suppose that the power of gravitation has only a feeble hold on those most minute dust particles at the altitude of 40 miles, where the atmosphere has not the many thousandth part of the density it has on the surface of the globe.

Mr. W. H. Preece writes stating his opinion that the mass of matter ejected retained the same electric sign as that of the earth, and as long as that was the case the repulsion force would be sufficient to keep the matter afloat; and in reference to that theory Mr. Crookes writes to state that with a rarefaction of one-millionth of the atmosphere, two pieces of electrified gold leaf repelled each other at a considerable angle for thirteen months, and goes on to state that that rarefaction is attained at

an altitude of 62 miles, and that the air there is a perfect non-conductor of statical electricity, without interfering with the mutual repulsion of similarly electrified particles; and when we bear in mind that the particles of minute dust are many thousands of times smaller and lighter than the gold leaves operated upon, there is every reason to believe that electrified dust, once projected 50 or 60 miles high, might remain there many years.

Before proceeding further I must draw your attention to the fact that at the time of the great eruption, and during September, the mean temperature at Batavia, and throughout Java generally, is at its maximum; consequently we may conclude that the equatorial belt of calms and uprushing air that encircle the globe was lying over that district at the time. This uprush is caused through the heated atmosphere rising, and the two trade winds, the north-east and south-east, feed it. When this heated air has attained its proper altitude, it flows off to the north and south, but the rotation of the earth causes it to flow towards the north-east in the Northern Hemisphere, and to the south-east in the Southern Hemisphere, and these winds are called by some the return trades, and by others the south-west and north-west upper currents respectively, and are of great altitude, probably ranging up to 50,000 feet.

Well, the most bulky masses cast upwards by the eruption of Krakatoa would immediately fall, and the less bulky would fall later according to their size, but the great portion of the dust and ash would be caught, on its downward course, in those upper currents just alluded to, and be carried by them to the north-east and south-east. Such we find to be the fact, for the ship *Meda*, when to the westward of Cape North-West, Australia, or about 1050 miles south-east of Krakatoa, experienced a fall of dust like fuller's earth, which covered the vessel, on the night of August 30-31, and Capt. Tierney, of the brig *Hazard*, on September 1, near New Ireland, a distance of 3850 miles due east of Krakatoa, saw the coloured suns, which was no doubt due to the presence of dust in the atmosphere, drifted eastward with the upper current.

Now, turning to the north-east quarter, or the direction in which the south-west upper current of the Northern Hemisphere proceeds, we find that in Japan during August 29, 30, and 31, the sun was of a copper colour, and had no brightness in it; at Yokohama, Mr. Hamilton states that on the 29th and 30th the sun was of a blood-red colour, and appeared to be obscured. This is at a distance of about 3000 miles from Krakatoa, which gives a velocity of the upper current, or return trade wind, of about 62 miles per hour; this is not excessive, as I have often measured the velocity of the north-west upper current at Adelaide as over 80 miles per hour.

You may remember that I did not continue the tracking of the dust cloud, from that position assigned to it by Capt. Penhallow, in lat. 24° N., long. 140½° W., on September 25, because the European and American reports are so peculiar. It was apparently seen in England *before* the rest of Europe, viz. on November 4 and 9, in California on the 20th, San Francisco on the 23rd, Italy on the 25th, New York on the 27th, and at Berlin on the 28th; so you see that the geographical arrangement is rather mixed in reference to the order of dates. This may be accounted for by the fact that there was a very severe volcanic eruption in the Alaska Group and Peninsula in October, I think; it was very intense, and quite capable of ejecting a dust cloud that would envelope the Polar and temperate regions of the Northern Hemisphere; of course it was not nearly so terrific as that of Krakatoa. So you will see that we must be careful before we assert that the brilliant sunsets of Europe are of Krakatoan origin.

The phenomena of coloured suns and brilliant sunsets, I may tell you, have been seen before, both in Europe and America, in connection with Vesuvian and Iceland outbursts; Mr. Somerville, the famous geographer, gives an instance of it which had been seen in Norway, and traced its origin to a severe eruption in Iceland. And H. C. Russell, B.A., F.R.A.S., F.R.Met.S., Government Astronomer, Sydney, in his book on the climate of New South Wales, pages 187, 188, gives some most interesting instances of historical accounts of darkened and coloured suns. I will quote them in their chronological order:—

"'At certain times the sun appears to be not of his wonted brightness, as it happened to be for a whole year when Cæsar was murdered, when it was so darkened that it could not ripen the fruits of the earth.' — Virgil, *Georg.*, lib. i., &c.

"In 1090 there was a darkening of the sun for three hours.

"In 1106, beginning of February, there was obscuration of the sun.

"In 1208 there was a darkening of the sun for six hours.

"In 1547, August 24 to 28, the sun was reddish, and so dark that several stars were visible at noonday.

"In 1706, May 12, about ten o'clock in the morning, it became so dark that bats commenced flying, and persons were obliged to light candles.

"In 1777, June 17, about noon, Messier states that he perceived an immense number of black globules pass over the sun's disk.

"In 1783 there was a *dry fog*, and many attributed it to volcanic action; and it is well known that in February that year fearful earthquakes in Calabria took place, followed by a long list of volcanic eruptions in other parts of the world.

"In 1831 was an extraordinary *dry fog*, which excited public attention throughout the world. It appeared on the

Coast of Africa	August	3
At Odessa	,,	9
In South France	,,	10
Paris	,,	10
New York	,,	15
Canton, China	,,	end of.

This fog was so thick that it was possible to observe the sun all day with the naked eye, and without a dark glass, and in some places the sun could not be seen till it was 15° or 20° high. At Algiers, United States, and Canton the sun's disk appeared of an azure blue or of a greenish colour. Where the fog was dense, the smallest print could be read even at midnight.

"In 1873, of the *dry fog* which came on suddenly in June, it is recorded that it extended from the northern coasts of Africa, over France to Sweden, and over great part of North America, and lasted more than a month. Travellers found it on the summit of the Alps. Abundant rains in June and July and most violent winds did not dissipate it; and in some places it was so dense that the sun could not be seen until it had attained an altitude of 12°, and throughout the daytime it was red, and so dull that it might be looked at with the naked eye. The fog diffused a disagreeable odour, and the humidity ranged from 57 to 68, while in ordinary fog it is 100. It had a phosphorescent appearance, and the light at midnight was compared to that of full moon."

Here was exhibited a diagram, drawn correctly to a scale of fifty miles to one inch, showing the arc (15°) of a circle whose radius was 6 feet 7 inches, or a diameter of 13 feet 2 inches. The Himalayas were shown in their correct proportion, so was the smoke from Cotopaxi, estimated by Whymper while on Chimborazo at 40,000 feet; he saw at 5.45 a.m. of July 30, 1880, a dense column of smoke shot up straight into the atmosphere with prodigious velocity, which in less than one minute had risen 20,000 feet above the crater, giving the total height of 40,000 feet above sea-level. The dust, he goes on to state, fell on Chimborazo after six hours, and he estimated that each particle did not weigh 1/25000 part of a grain, and the finest were still lighter.

Some people (and very rightly too) express wonder and unbelief at the possibility of *dust* being capable of having been shot up to such a height as that ascribed to it, as to cause the red sunsets,—but here I have quoted the fact of such, as seen by a man of known repute; the dust and ashes *were shot up* to that great height, and not only that, but as the dust cloud came between Mr. Whymper and the sun, he saw the phenomenon of the coloured suns. The same may be seen during any very heavy dust storm anywhere, when the cloud is between the observer and the sun.

In this description given by Whymper, we have a good illustration of the tremendous force Nature uses in these convulsions; a force that could throw the finest dust to a *height* of 20,000 feet is almost inconceivable to the human mind, and in that phenomenon we have, I may say, only an everyday occurrence when compared with that giant eruption of Krakatoa. Let us draw a comparison. At the destruction of Pompeii, situated at the *foot* of Vesuvius, the city was enveloped with darkness from the density of the dust and ash cloud that enshrouded it, and that ultimately buried it; but now contemplate the tremendous power that ejected from a mountain a sufficiency of dust and ash

envelop a city in total darkness for thirty-six hours, *eighty miles distant*. On that diagram I have sketched an imaginary picture of the eruption, and eighty miles distant is represented by a little over an inch and a half, where you see the letter B, showing to your mind the relative distance of Batavia from Krakatoa. You can form in your imagination some idea of the great height that the dust cloud ascended: to my mind twice forty would not be too great. Then again we have the ship *Charles Bal*, when *thirty miles distant*, was enveloped at noon-day in pitch darkness through the mud-fall. Furthermore, as Lockyer says, the sound, the least part of the affair, was heard over an area of 4000 miles in diameter, viz. in Ceylon to the north-west, at Saigon to the north, and throughout North Australia to the south-east. In the last quarter the reports were at intervals of fifteen minutes, and sounded like ship-guns, but as the hearers were from 150 to 200 miles from the coast, such cause could not be assigned. All that can be said is that it is beyond the human mind to conceive of such gigantic forces, and therefore absurd to throw doubt on the result; by which I mean that if the laws of refraction show that the substance, whatever it may be, that causes the red glow, is at an altitude of forty or sixty miles, it is ridiculous to doubt that result, when we cannot conceive the magnitude of the power that operated.

It was not only one eruption that took place, but several, during the 26th, the following night, and up to 11.15 a.m. of the 27th, about which time the grand finale is supposed to have taken place. These eruptions followed each other in rapid succession, and are thought to have been caused by the rapid conversion into steam of vast quantities of water that found admittance into the bowels of the earth. Later on the influx of water was too much, and the result was that a tremendous power was generated, so much so as to cause the north part of the island to be blown away, and fall eight miles to the north, forming what is now called Steers Island. This was followed by a still greater eruption, when it is thought that the north-east portion was blown clean away, passing over Long Island, and fell at a distance of seven miles, forming what is now known as Calmeyer Island. These suppositions are almost proved to be facts, from the Marine Survey of the Straits just concluded, from which it will be seen that the bottom surrounding these new islands has not risen, which would most naturally have been the case had they been caused by upheaval, but if anything the bottom shows a slightly increased depth in the direction of the great pit that now occupies the position that the peak of Krakatoa did the day before. These incidents are cited to show you the awful nature and magnitude of the forces brought into play, as you can the more readily satisfy your minds as to the great height the dust and ash were thrown to.

As I said before, this dust cloud may probably be denser in some places than others, owing that fact to the relative period of time that elapsed between each eruption; where it is dense we may assume that they followed each other rapidly, and where it is less dense the interval of time was greater. For you must remember that it was shown to you that the cloud apparently moves to the westward, or that the earth moves from beneath the cloud, at the rate of 87 miles per hour, so that during each hour of the eruption there was a long streak of smoke and dust being formed. These densest parts were no doubt the cause of the coloured suns, and as some observers state, "the sun appeared to shine with diminished strength," others "that it was rayless and giving no heat," so we may look upon that dust cloud as playing the part of a great screen, shutting off some of the heat of the sun from us. In these southern latitudes we have experienced those brilliant sunsets for over seven months, and I have no hesitation in expressing my opinion that the remarkably cool and wet summer just passed in New Zealand was due to that dust cloud shutting off the sun's heat in a great degree. And I see from the Adelaide report that the mean temperature there during January was over 4½ degrees cooler than the average of the previous twenty-five years, and on only one occasion during that period was it so low, viz. in 1869. At Melbourne also the weather was more like winter than summer, whereas in North and Central Australia, or I may say down to lat. 30° on that continent, the weather was fine, clear, and hot, without rain, giving me the idea that the sun had less power than usual; consequently the north-west monsoon was very feeble, not penetrating far inland, the result being that the interior of Australia has undergone one of the most disastrous droughts on record. But now that, as we may suppose, the equatorial regions of the atmosphere have parted with the greater part of their dust, if not all, the sun has regained his usual power, and the north-west monsoon its usual strength, penetrating the heart of Australia with refreshing rains and thunderstorms. So we have here an instance of a most terrific phenomenon that not only brought death and destruction to thousands at the time, but that indirectly caused the death of thousands and thousands of cattle and sheep through drought, and it would be most interesting and instructive to learn whether or not such consequences were experienced in other parts of the Southern Hemisphere at least.

It would be beyond the province of this paper, and in fact too late to-night, to enter on a history of the tidal and atmospheric waves that resulted from this eruption, but I will state two facts to finally clinch your mind of its magnitude. When the earth opened her mouth and swallowed that vast quantity of water, the down-rush that accompanied the closing-in of the surrounding crust was so much as to produce a tidal wave that passed and repassed twice, I believe, round the globe. The other fact is, that the tremendous explosion that accompanied the final eruption produced such a vacuum as to cause atmospheric waves to start, and which traversed and retraversed the earth to the antipodes of Krakatoa no less than four times.

Some astronomers have thought that the whole phenomenon may be accounted for by supposing the earth to be passing through a dense meteoric track. To my mind, however, the greatest difficulties brought to bear against the volcanic theory are child's play when compared with the possibility of about 10,000,000,000 to one of a meteoric track so formed as to have its path, either at aphelion or perihelion, so remarkably coincident with that of the earth as to keep company with her for seven or eight months. Besides, were it either meteoric or cosmic dust, it would be seen all over the earth at the same time, and would be visible all night.

No; the only extra-terrestrial argument that would bear any investigation is that of its belonging to the phenomenon of the zodiacal light, which argument, I believe, was adopted at first by my friend Charles Todd of Adelaide; but, as time goes on and more information is gathered, the volcanic theory, I believe, will be finally adopted.

THE THEORY OF THE WINTER RAINS OF NORTHERN INDIA [1]

AT first sight, the occurrence of rain in Northern India at the season when the north-east or winter monsoon is at its height seems to present a meteorological paradox. The well-known theory of the winter monsoon is that at that season the barometer stands highest in North-Western India where the air is cold and dry, and lowest in the neighbourhood of the equator where it is warm and moist; and therefore, in accordance with elementary mechanical laws, the wind blows from the former to the latter. But the precipitation of rain requires that the air should have an ascending movement, and this can take place only over a region of low barometer, towards which, therefore, the winds are pouring in. Hitherto no one has attempted the reconciliation of these apparently discrepant conditions.

Since the establishment of a Meteorological Department under the Government of India has rendered it possible to study the weather of India as a whole from day to day, it has been my practice to investigate every case of cold weather rainfall in Northern India, amounting generally to three or four in each year, and although many important points still remain for elucidation, it is now at least possible to clear up many of the difficulties of the problem, and to reconcile the apparent inconsistencies.

The charts which accompany the paper show the distribution of atmospheric pressure and the prevalent winds in the four months of the cold weather. They exhibit many features in common. The region of highest barometer is in the Punjab and the Indus Valley, and from this an axis or ridge of high pressure extends across Rajputana and Central India, having a trough of slightly lower pressure in the Gangetic plain and the Northern Punjab on the one hand, and a much lower pressure in the peninsula on the other. The winter monsoon blows around this region of high pressure in an anticyclonic curve, *i.e.* in the direction of the watch-hands, but in the Punjab and the Gangetic plain there is but little movement of the air, the average rate

[1] Abstract of a paper read before the Asiatic Society of Bengal on March 5, 1884, by H. F. Blanford, F.R.S., President of the Society.